A comparison of techniques for obturating oval-shaped root canals

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This study compared the effectiveness of three obturation techniques for oval-shaped canals. Roots of 42 extracted teeth with oval canals were randomly divided into three groups: (1) ProTaper canal preparation and single cone obturation with matching gutta-percha point; (2) ProTaper preparation plus thermoplastic obturation (Thermafil); (3) Profile .06 taper and matching master cone with lateral condensation. Cross-sectional area of the canal space occupied by sealer cement and gutta-percha was measured in the coronal, middle, and apical thirds using an image analysis software. The percentage of the cross-sectional shape occupied by sealer cement was calculated. The Thermafil group was significantly lower than the single cone group or the lateral condensation group in the middle third (p<0.01) and lower than the single cone group in the coronal third (p<0.05). There were no significant differences between the single cone obturation group and the lateral condensation group in each level.

Keywords: Obturation, Oval canals, Sealer cement

INTRODUCTION

Oval- or ribbon-shaped canals occur in approximately 25% of teeth¹¹. The preparation and obturation of these canals pose a challenge. The extremities are often untouched by instruments, whether prepared by hand or rotary instrumentation or with the use of specifically designed devices²⁵. Rotary nickel-titanium (NiTi) instruments tend to prepare a central circular bulge, with uninstrumented extensions buccally and lingually³. Thus, the prepared canal is often very irregular in shape.

Obturation of irregularly-shaped canals will also be more difficult than for canals with round profiles and smooth taper. Lateral condensation does not reliably result in complete obturation of uninstrumented recesses⁶. Thermoplastic techniques offer the potential for obturation equivalent to or better than lateral condensation⁴⁸, and are likely to be less dependent on the canal shape than condensation. Canals prepared using rotary NiTi instruments can be obturated with a single cone of the same size and taper as the largest instrument. Although the single cone technique offers little opportunity for filling irregularities and recesses, the outcome in extracted teeth and simulated canals was comparable with that achieved using lateral condensation⁹.

In this study, the effectiveness of three obturation techniques was compared following rotary NiTi preparation of oval canals of extracted teeth: lateral condensation, a matching single cone technique, and a thermoplastic technique (Thermafil). The effectiveness of obturation was determined by measuring the percentage of the cross-sectional profile of the obturated canal occupied by sealer and gutta-percha, and also the number of voids as well as the percentage of the canal area occupied by voids, using an image analysis software. The apical, middle, and coronal thirds were analyzed separately.

A commonly accepted ideal for obturation is maximal volume of the core material and minimal thickness of sealer cement¹⁰⁻¹². The objective of this study was to determine whether irregularly shaped canals following rotary NiTi preparation can be more effectively obturated using a thermoplastic technique than the new matching single cone obturation technique or a lateral condensation on each part. The null hypothesis of this study was that the percentage of the cross-sectional area occupied by gutta-percha versus sealer cement was not different for the three obturation techniques.

MATERIALS AND METHODS

Selection of teeth

This study was approved by the Departmental Human Ethics Advisory Group of the School of Dental Science, University of Melbourne, and teeth (which were extracted for reasons unrelated to the study) were obtained with the informed consent of patients. Mandibular premolars with fully formed
apices and an oval-shaped canal were selected. The presence of an oval canal was verified radiographically in buccolingual and mesiodistal directions. Canal width was estimated from the radiographs and only canals with a long:short ratio > 2:1 at a distance of 5 mm from the root apex were included. Forty-two teeth were randomly divided into three treatment groups using a random number table.

**Canal preparation**
Crowns of the teeth were left intact to simulate clinical conditions. Following coronal access, working length was determined at 0.5 mm from the apical foramen using a #10 hand file, by visual observation. Canals were then prepared using rotary NiTi instruments, with copious irrigation using 1% sodium hypochlorite. The smear layer was removed after canal enlargement was completed, with 5 ml of 1% sodium hypochlorite followed by 10 ml of 15% EDTA and then again with a final rinse using 5 ml of 1% sodium hypochlorite. Canals of 28 teeth were prepared using ProTaper instruments (Dentsply Maillefer, Ballaigues, Switzerland) to size F2 or F3, and another 14 teeth were prepared with ProFile ISO Rotary Instruments (Dentsply Maillefer, Ballaigues, Switzerland) to size 35 or 40.06 taper.

**Obturation**
Canals were dried using paper points. An epoxy-based sealer cement (AH Plus, DeTrey Dentsply, Konstanz, Germany) colored with a small amount of Sudan Black B (Poly Scientific Research and Development Corp., Bay Shore, NY, USA) was placed in the canals using a lentulo spiral. The 28 canals prepared with ProTaper to F2 or F3 respectively were obturated using one of the following two techniques:

2. Thermafil (Tulsa Dental Products, Tulsa, OK, USA) size 25 or 30, in canals (14 roots): Thermafil group.

The remaining 14 canals prepared with ProFile to size 35 or 40.06 taper were obturated using the following technique:

3. Lateral condensation using Profile 35 or 40.06 taper gutta-percha master cone (Dentsply Maillefer) and extra fine accessory points: Lateral condensation group.

All teeth were stored at 37°C in 100% humidity for 48 hours after obturation.

**Sample preparation and analysis**
The root section between the cemento-enamel junction and a point 0.5 mm above the apical foramen was divided into three equal sections perpendicularly to the long axis of the canal. The sections were labeled apical third, middle third, and coronal third. This was performed using a 0.3-mm-thick diamond blade at slow speed with constant water-cooling. Surfaces were polished using 600-grit sandpaper, rinsed thoroughly under running water, dried and photographed under standardized conditions at ×6, ×12, and ×25 magnification using a digital camera attached to a microscope.

Cross-sectional area of the canal space occupied by sealer and gutta-percha was measured using an image analysis software (ImageJ1.35d; National Institutes of Health, USA). The cross-sectional areas occupied by sealer cement and by the voids were then calculated as a percentage of the total cross-sectional area of the canal. The number of voids present was also recorded.

Obtained data on the percentage of sealer cement area/total canal area were analyzed using a Kruskal–Wallis analysis to determine the significance of differences among the three groups. Post hoc comparisons among groups and levels were conducted using a Scheffé’s test.

**RESULTS**
In the apical third, canal preparations were generally round or slightly oval-shaped. However, in the middle and coronal thirds, the canals retained a predominantly ribbon-shaped cross-sectional shape (Fig. 1). A central bulge corresponding to the largest NiTi file used was frequently present. Gutta-percha was generally well adapted to the canal shape in the apical thirds. In the coronal and middle thirds, Thermafil filled most of the canal space, with the carrier centered within the mass of gutta-percha. The single cone group relied more heavily on sealer cement in the coronal and middle thirds. In the lateral condensation group, accessory points rarely reached the apical third and showed variable condensation in the coronal and middle thirds. Sudan Black B dye demonstrated extensive penetration of sealer cement into dentinal tubules with all obturation techniques.

The percentage of the cross-sectional shape occupied by sealer cement revealed a wide variation with all obturation techniques, but was lowest in the Thermafil group at all levels. The percentage occupied by sealer cement in the Thermafil group was significantly lower than the single cone obturation group or the lateral condensation group in the middle thirds (p<0.01) and lower than the single cone group in the coronal thirds (p<0.05). There were no significant differences between the single cone obturation group and the lateral condensation group in each level (Fig. 2).
The amount of locations with voids was similar in all groups, but greater in the middle and coronal thirds, where 57–71% of all roots showed voids. When present, most voids were small, occupying less than 5% of the total cross-sectional area (Table 1). Most of the values were 0, so it would be meaningless to calculate the significant differences.

### Table 1  Amount of locations with voids (%) and Σ (voids area)/Σ (total area) as a percentage

<table>
<thead>
<tr>
<th>Location</th>
<th>Single cone</th>
<th>Thermafil</th>
<th>Lateral condensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical</td>
<td>3 (21.4%)</td>
<td>3 (21.4%)</td>
<td>7 (53.8%)</td>
</tr>
<tr>
<td></td>
<td>3.1%</td>
<td>0.9%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Middle</td>
<td>8 (57.1%)</td>
<td>9 (64.3%)</td>
<td>8 (61.5%)</td>
</tr>
<tr>
<td></td>
<td>4.5%</td>
<td>0.7%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Coronal</td>
<td>10 (71.4%)</td>
<td>9 (64.3%)</td>
<td>9 (69.2%)</td>
</tr>
<tr>
<td></td>
<td>9.7%</td>
<td>1.5%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

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DISCUSSION

The difficulty of preparing oval canals with a smooth round profile, with a continuous taper from apical to coronal2-5 was confirmed in this study. Findings revealed that only the apical third exhibited a consistently smooth, round shape1,13. Therefore, obturation of oval canals depended to a considerable extent on sealer cement or on the Thermafil group that permitted the flow of gutta-percha into unprepared recesses of the canal. The percentage of voids was very small overall, and hence we could ignore the voids in this study.

Evaluation of the quality of obturation has commonly relied on either apical or coronal leakage, despite the poor reproducibility among studies and their uncertain clinical significance14. Therefore, techniques that measure the thickness of the sealer layer or the ratio of sealer cement to gutta-percha are often preferred, on the premise that the best long-term seal is achieved with a minimal sealer cement thickness10,12,19. Sealer cements tend to undergo setting contraction10 and dissolve over time10,16, which may predispose the filling to leakage and ultimately provide an avenue for reinfection of the canal space.

The Thermafil group provided the best outcome in terms of adaptation to the canal shape and sealer: gutta-percha ratio, especially in the middle and coronal thirds, which was consistent with previous reports of more regularly shaped canals12,17-19. Despite the reported effectiveness of a matched-taper single cone technique in obturating canals prepared with rotary nickel-titanium instruments8, its ability to fill an oval or irregular canal space was clearly diminished by its shape.

The three techniques were found to be comparable in the apical third, where the canal space was predominantly round and that the taper of the master cone matched the taper of the prepared canal. Furthermore, the percentage of the cross-sectional area occupied by gutta-percha was not significantly different at any level between the single cone group and lateral condensation group with the matching gutta-percha point for cold obturation techniques. This was comparable to the findings of Gordon et al.9. Although the aim of lateral condensation is to fill the space surrounding the master cone with gutta-percha by the use of accessory points, no benefit was noted in this study. Lateral condensation may be less effective when used in association with increased taper master cones (0.06 taper in the present study), which leave less space available for accessory points. An accessory point was rarely observed in cross-sections of the apical third. Therefore, under the parameters of this study, where most canals were prepared round shapes, the single cone technique using a ProTaper matching gutta-percha point that is simpler and faster than other obturation techniques was acceptable for filling canals, especially at the apical third. Wide variability within each group, reflecting the natural variation among teeth as well as variability in the effectiveness of canal preparation, limited the ability to demonstrate statistically significant differences.

In this study, the addition of Sudan Black dye to the epoxy-based sealer cement provided a strong color contrast for measuring the sealer:gutta-percha ratio, and for demonstrating the extent of sealer penetration into the dentinal tubules12. The addition of dye to the sealer has been shown not to affect the working properties of the sealer, and the extent of sealer penetration has been confirmed using scanning electron microscopy20. The clinical significance of relying on sealer cement to fill 30% or more of the middle and coronal thirds of the canal is unknown.

Sealer cement was generally present as a continuous layer around the canal wall with all obturation techniques, unless a void was present at the extremity of a canal recess. As in an earlier study12, the consistent, extensive penetration of sealer cement into dentinal tubules was demonstrated regardless of the obturation technique at all levels.

The extensive penetration of the epoxy resin-based sealer used in this study confirmed the result of Weis et al.12, and that this intimate bond with dentin via dentinal tubule penetration should resist bacterial leakage. The potential for leakage between the sealer cement and gutta-percha20 is not likely to be substantially different among the obturation techniques used in this study. Thus, unless coronal or apical leakage occurs, resulting in the gradual dissolution of the sealer cement, there may be little difference between filling the canal space with sealer cement versus gutta-percha.

CONCLUSIONS

1. The obturation technique had little impact on the quality of obturation in the apical third.
2. A thermoplastic technique led to better adaptation of gutta-percha to the canal space and less reliance on sealer cement in the middle and coronal thirds.
3. Sealer cement penetrated dentinal tubules very extensively with all obturation techniques.

REFERENCES